US009075209B2

(12) **United States Patent**
Liu et al.

(10) **Patent No.: US 9,075,209 B2**
(45) **Date of Patent: Jul. 7, 2015**

(54) **OPTICAL MODULE HAVING ADDITIONAL LENS FOR DIFFERENT CONNECTION**

(71) Applicant: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(72) Inventors: **Jia-Hau Liu**, New Taipei (TW); **Yuan-Chieh Lin**, Lake Forest, CA (US)

(73) Assignee: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/919,148**

(22) Filed: **Jun. 17, 2013**

(65) **Prior Publication Data**

US 2014/0369650 A1 Dec. 18, 2014

(51) **Int. Cl.**
G02B 6/36 (2006.01)
G02B 6/42 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 6/4295*** (2013.01); ***G02B 6/4204*** (2013.01); ***G02B 6/4214*** (2013.01); ***G02B 6/425*** (2013.01)

(58) **Field of Classification Search**
USPC 385/79
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,393,184 B1 *	5/2002	Day et al.	....	385/49
7,418,165 B2	8/2008	Glebov et al.		
7,680,367 B2	3/2010	Matsuoka et al.		
2012/0141070 A1	6/2012	Sabo		
2012/0308188 A1	12/2012	Chien et al.		
2014/0050442 A1 *	2/2014	Wurster et al.	....	385/50

* cited by examiner

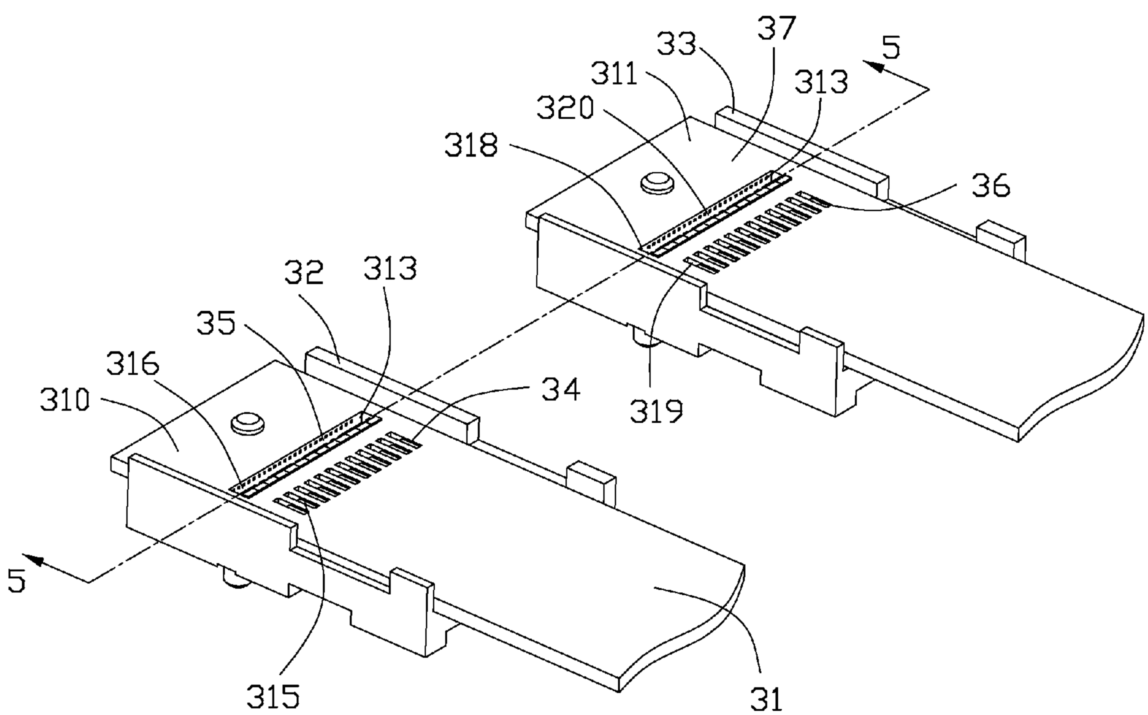
Primary Examiner — Jerry Blevins

(74) *Attorney, Agent, or Firm* — Ming Chieh Chang; Wei Te Chung

(57) **ABSTRACT**

An optical module (**30**) includes an optical waveguide (**31**), a first ferrule and a second ferrule (**32**, **33**) connected with the optical waveguide. The optical waveguide includes 2N optical channels (**313**). The first and the second ferrules includes N mirrors (**34**, **36**) and N+1 lenses (**35**, **37**). N of the 2N optical channels optically couple the N mirrors (**34**) of the first ferrule with N of the N+1 lenses (**37**) of the second ferrule, and the remaining N of the 2N optical channel couple N of the N+1 lenses (**35**) of the first ferrule with the N mirrors (**36**) of the second ferrule.

17 Claims, 8 Drawing Sheets



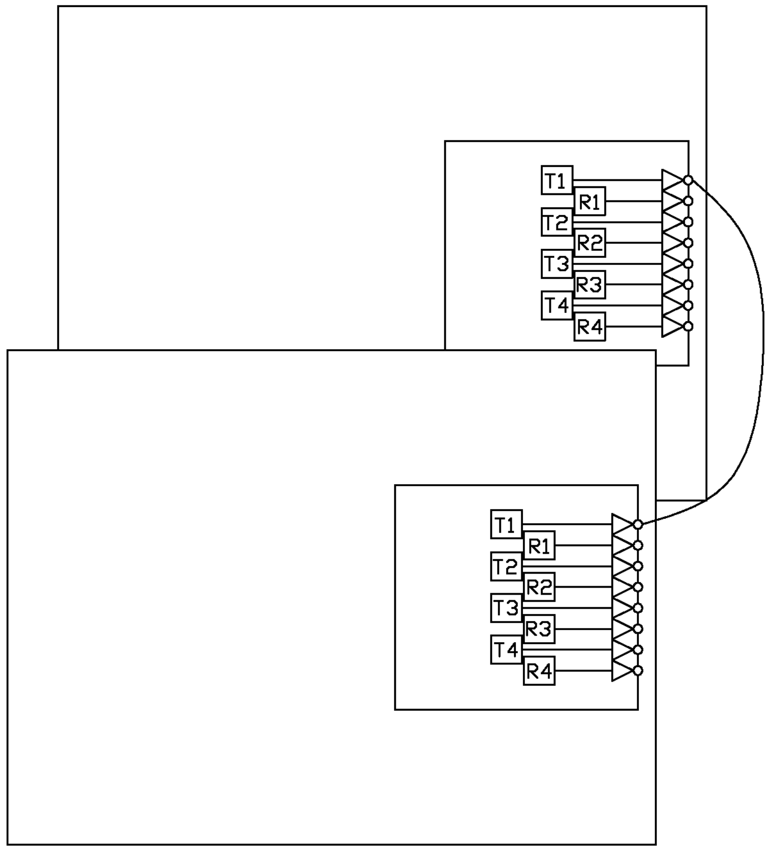
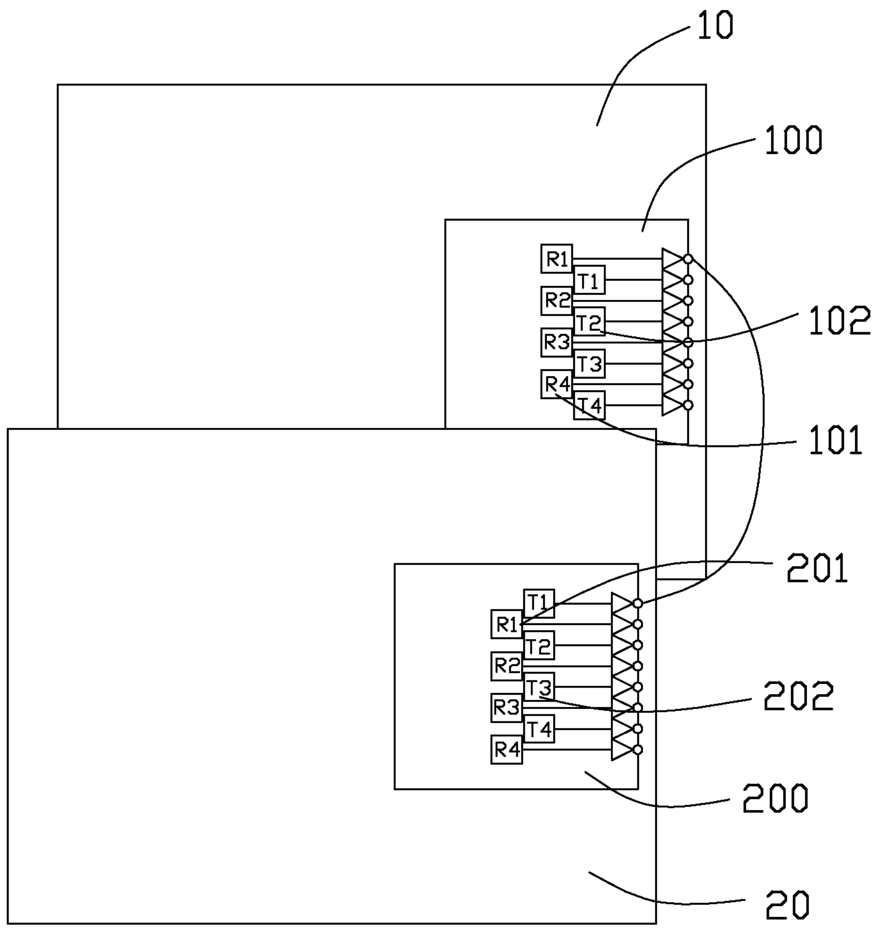


FIG. 1



10
100
R1
T1
R2
T2
R3
T3
R4
T4
102
101
201
T1
R1
T2
R2
T3
R3
T4
R4
202
200
20

FIG. 2

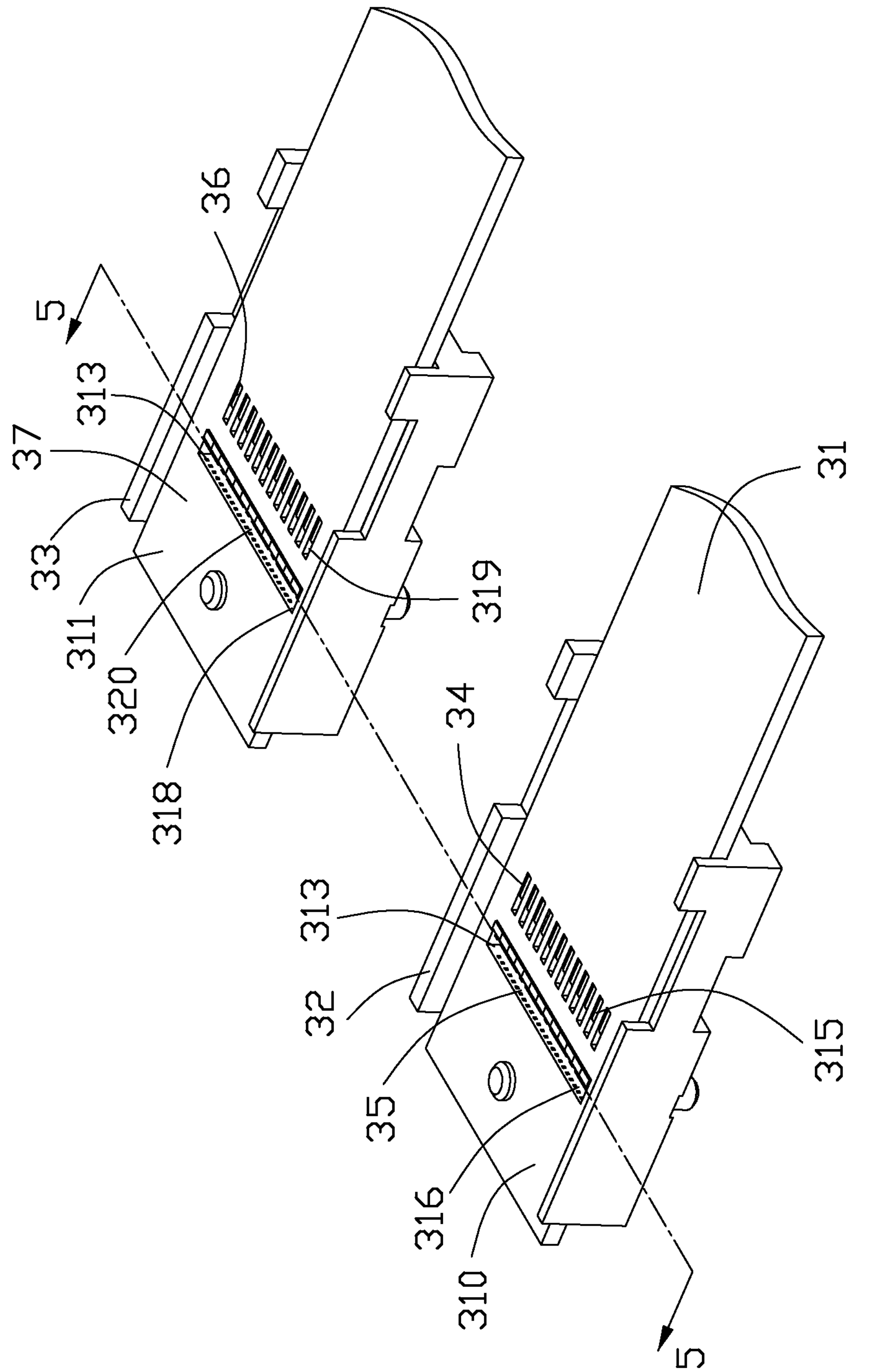


FIG. 3

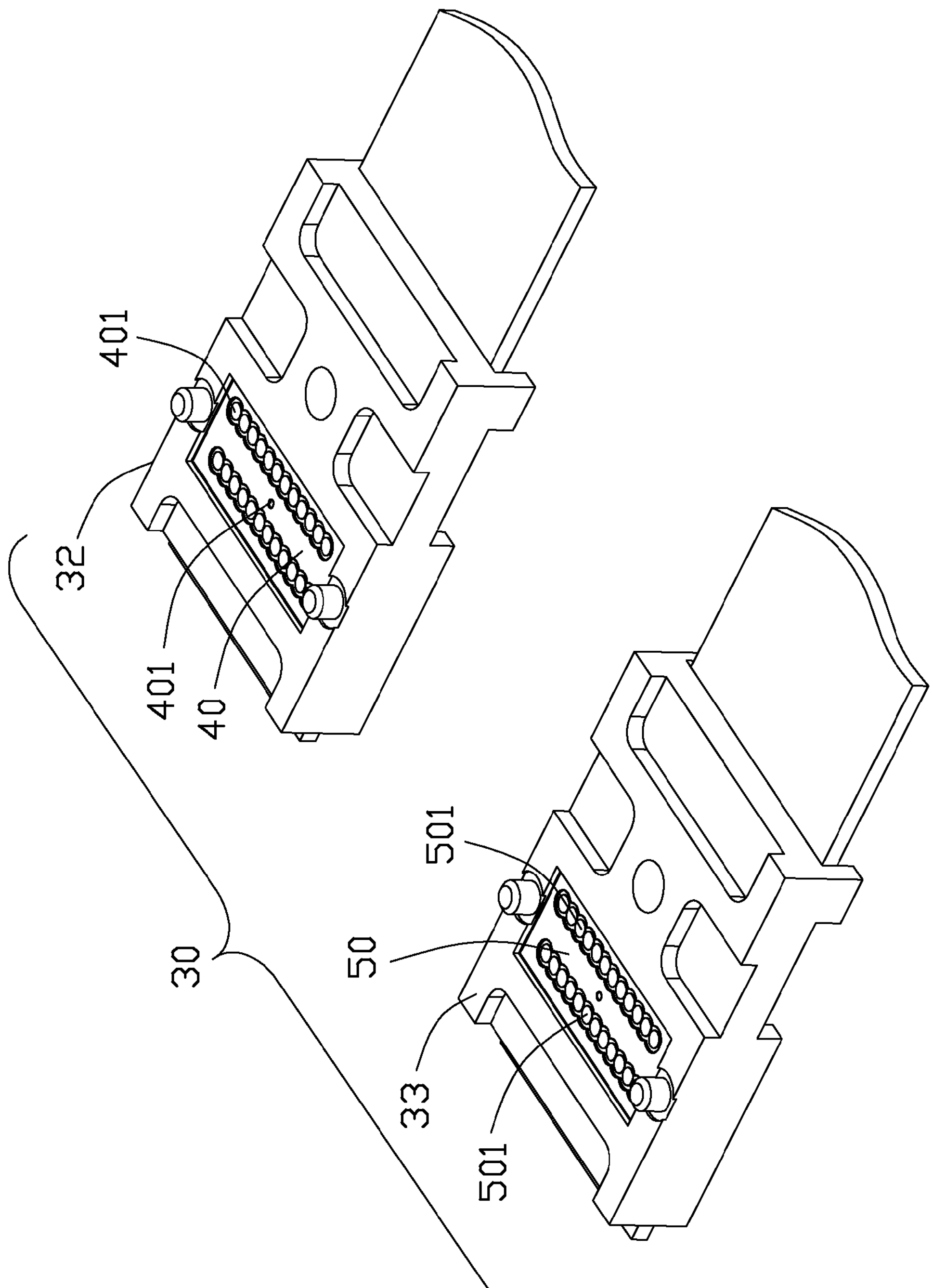


FIG. 4

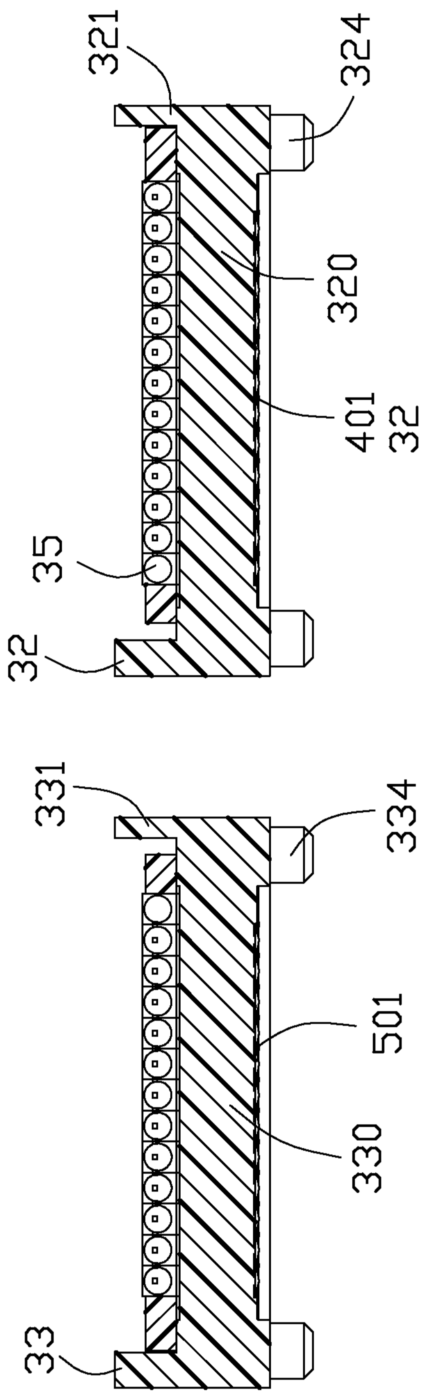


FIG. 5

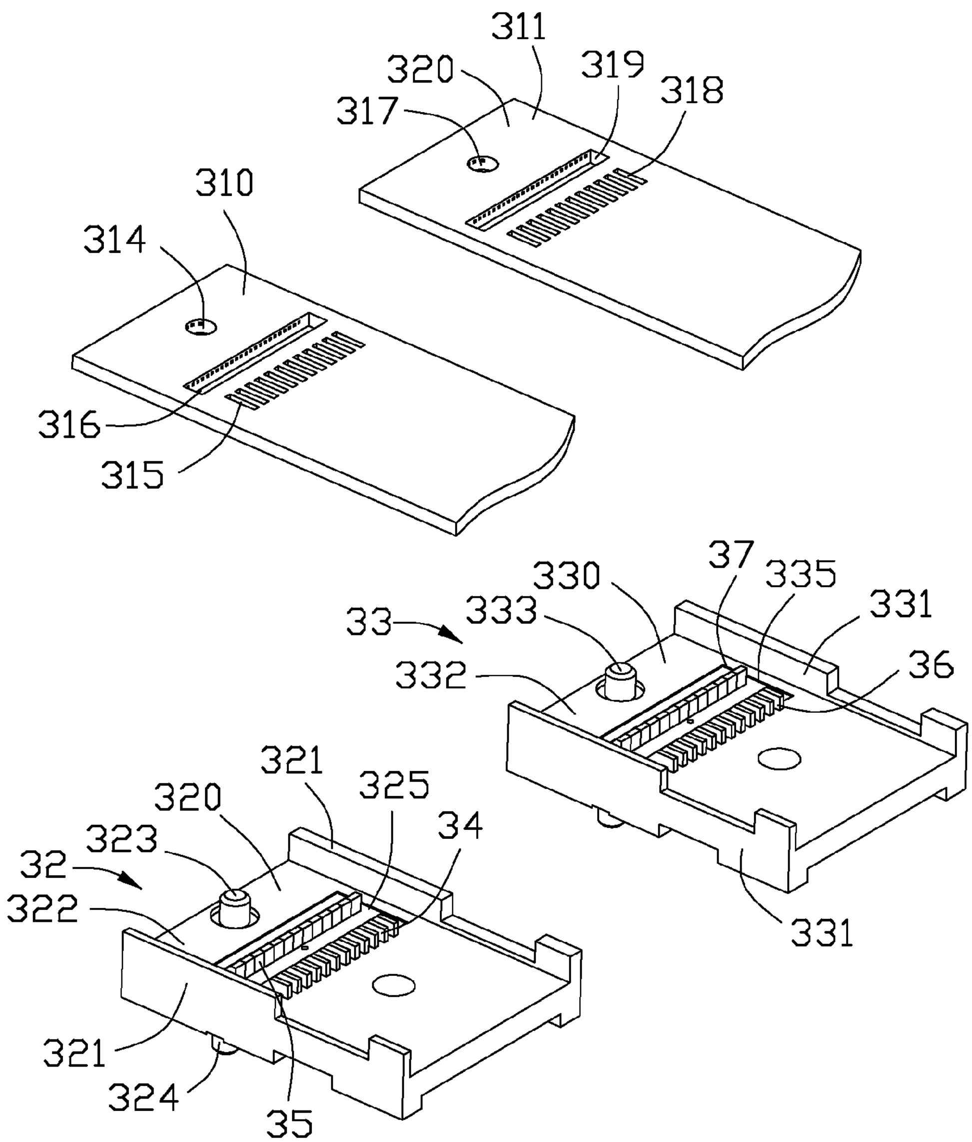

311
320
319
318
317
310
314
316
315
37
330
335
33
333
331
332
36
321
325
320
34
323
32
322
331
321
324
35

FIG. 6

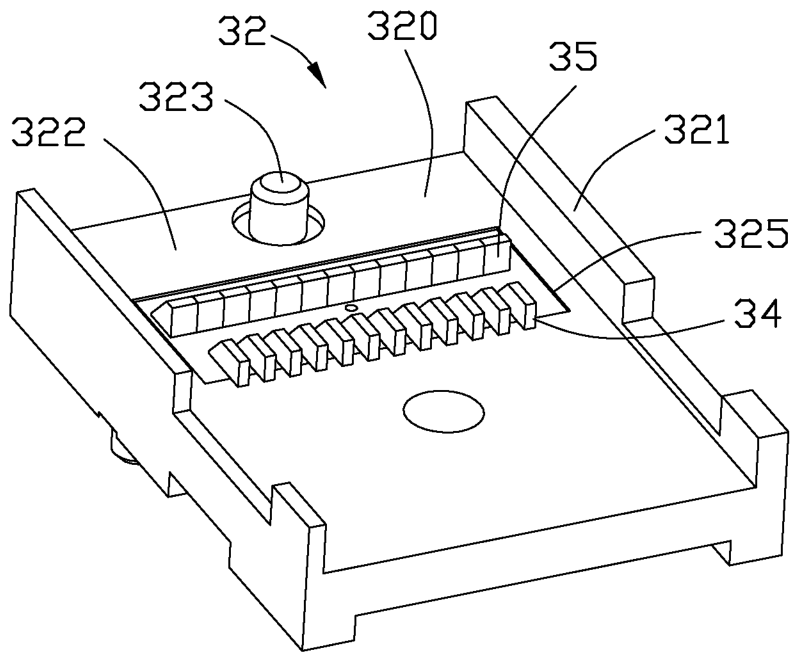


FIG. 7

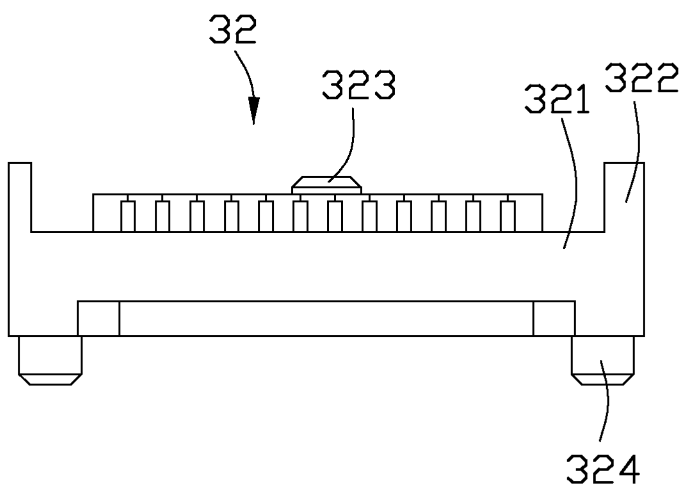


FIG. 8

OPTICAL MODULE HAVING ADDITIONAL LENS FOR DIFFERENT CONNECTION

CROSS REFERENCE TO RELATED APPLICATION

This application relates to a copending patent application Ser. No. 13/595,113 filed Aug. 27, 2012 and titled "OPTICAL MODULE FOR TRANSMITTING OPTICAL SIGNAL."

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical module, and more particularly to an optical module for optical communication application.

2. Description of Related Arts

Referring to FIG. **1**, an optical backplane system comprises a backplane, a plurality of switch cards mounted to the backplane, and a plurality of line cards mounted to the backplane. The switch cards and line cards are inserted into the backplane system along a same direction. The lines cards are connected with the switch cards using optical modules. Each of the line cards and the switch cards comprises a plurality of transmitters T**1**-T**4** of same arrangement and a plurality of receivers R**1**-R**4** of same arrangement. It is needed to design a transmitter at an end of the optical medium and a receiver in the other end of the optical medium. If all of the switch cards and the line card have a plurality of transmitters and receivers with a same arrangement, a straightforward coupling would result in the transmitters of the switch cards coupling to the transmitters of the line cards and the receivers of the switch cards coupling to the receivers of the line cards, which is impracticable.

U.S. Patent Application Publication No. 2012/0308188, published on Dec. 6, 2012, to Chien et al. discloses a similar optical backplane system. The optical backplane system comprises a backplane, a pair of switch cards mounted to the backplane, a plurality of line cards mounted to the backplane and disposed parallel to the switch cards. All of the switch and the line cards comprise a plurality of optical connecting portions. The optical backplane assembly further comprises an optical connecting member to couple the optical connecting portions of the line cards with the optical connecting portions of the switch cards. U.S. Pub. No. 2012/0141070, published on Jun. 7, 2006, discloses an optical connector assembly used for connecting cards of a backplane system. U.S. Pat. No. 7,418,165, issued on Aug. 26, 2008, to Glebov et al., and U.S. Pat. No. 7,680,367, issued on Mar. 16, 2010, to Matsuoka et al. disclose optical signal transmission in optical medium. An improved optical module is desired to offer advantages over the related art.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an optical module with the two ends could be assembled to different types to mate with different ports.

To achieve the above-mentioned object, an optical module comprises:

an optical waveguide having a first end and a second end opposite to the first end, the optical waveguide comprising 2N optical channels extending between the first end and the second end;

a first ferrule connected with the first end of the optical waveguide, the first ferrule comprising N first mirrors

arranged in one row, and N+1 first lenses arranged in another row, the first lenses disposed spaced apart from the first mirrors; and

a second ferrule connected with the second end of the optical waveguide, the second ferrule comprising N second mirrors arranged in one row, and N+1 second lenses arranged in another row, the second lenses disposed spaced apart from the second mirrors;

wherein N of the 2N optical channels optically couple the N first mirrors with N of the N+1 second lenses, and the remaining N of the 2N optical channels couple N of the N+1 first lenses with the N second mirrors.

According to the present invention, the waveguide could be adjusted to establish connections between the first lenses and the second mirrors or the first mirrors and the second lenses.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a sketch view of a switch card and a line card of a prior art backplane assembly;

FIG. **2** is a sketch view of a switch card and a line card in accordance with the present invention;

FIG. **3** is a perspective view of an optical module in accordance with the present invention;

FIG. **4** is another perspective view of the optical module as shown in FIG. **3**;

FIG. **5** is a cross-sectional view of the optical module taken along line **5**-**5** of FIG. **3**;

FIG. **6** is an exploded view of the optical module as shown in FIG. **3**;

FIG. **7** is a perspective view of the first or the second ferrule of the optical module as shown in FIG. **3**; and

FIG. **8** is a back side view of the first or the second ferrule of the optical module as shown in FIG. **7**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to a preferred embodiment of the present invention.

Referring to FIG. **2**, an backplane assembly **1** comprises a backplane (Not shown), a plurality of switch cards **10** (Only one is shown) mounted to the backplane, a plurality of line cards **20** (Only one is shown) mounted to the backplane, and a plurality of optical modules **30** optically coupling with the switch cards **10** and line cards **20**. The switch cards **10** and the line cards **20** are arranged side by side. The switch card **10** comprises an OE module **100** comprising a plurality of receivers **101**, such as photodiodes, arranged in a row, and a plurality of transmitters **102**, such as VCSELs, arranged in another row. Each of the receivers **101** are upwardly moved a half pitch with corresponding one transmitter **102**. The line card **20** comprises an OE module **200** comprising a plurality of receivers **201**, such as photodiodes, arranged in a row, and a plurality of transmitters **202**, such as VCSELs, arranged in another row. Each of the receivers **201** are downwardly moved a half pitch with corresponding one transmitter **202**.

Referring to FIGS. **3** to **6**, the optical module **30** comprises a optical waveguide **31** having a first end **310** and a second end **311** opposite to the first end **310**, a first ferrule **32** connected with the first end **310** of the optical waveguide **31**, and a second ferrule **33** connected with the second end **311** of the optical waveguide **31**. The optical waveguide **31** is made from polymer material. The optical waveguide **31** comprises 2N optical channels **313** extending between the first end **310** and the second end **311**. The optical channels **313** are arranged in a row. Each of the channels **313** is spaced apart a pitch from adjacent one. The first end **310** of the optical waveguide **31** defines a first through hole **314**, a plurality of first holes **315** arranged in a first row and spaced apart a pitch from adjacent one, and a first slot **316** disposed between the first through hole **314** and the first holes **315**. The first slot **316** extends along a direction parallel to the first row. The second end **311** of the optical waveguide **31** defines a second through hole **317**, and a plurality of second holes **318** arranged in a second row and spaced apart the pitch from adjacent one, and a second slot **319** disposed between the second through hole **317** and the second holes **318**. The second slot **319** extends along a direction parallel to the second row.

Referring to FIGS. **3** to **8**, the first ferrule **32** comprises a first bottom wall **320**, and a pair of first side walls **321** respectively projecting upwardly from sides of the first bottom wall **320**, and a first receiving space **322** formed by the first bottom wall **320** and the first side walls **321**. The first bottom wall **320** comprises a first post **323** projected into the first receiving space **322**, and a pair of first mounting post **324** for being mounted to an outer device. The first bottom wall **320** defines a first receiving hole **325** extending therethrough. The second ferrule **33** comprises a second bottom wall **330**, and a pair of second side walls **331** respectively projecting upwardly from sides of the second bottom wall **330**, and a second receiving space **332** formed by the second bottom wall **330** and second receiving space **331**. The second bottom wall **330** comprises a second post **333** projected into the second receiving space **332**, and a pair of second mounting post **334** for being mounted to an outer device. The second bottom wall **330** defines a second receiving hole **335** extending therethrough.

The first ferrule **32** comprises N first mirrors **34** arranged in a row, and N+1 first lenses **35** arranged in another row, the first lenses **35** disposed spaced apart from the first mirrors **34**. The first lenses **35** are arranged side by side, and the first mirrors **34** are arranged spaced apart from each other. Each of the first lenses **35** is offset with corresponding one first mirror **34**. The first lenses **35** and the first mirrors **34** are disposed on the first bottom wall **320**. The first lenses **35** are disposed closer to the first post **323** than the first mirrors **34**. The N first mirrors **34** are received in the first holes **315**, respectively, with each first mirrors **34** optically coupling with corresponding one of the optical channels **313**. The N of the N+1 first lenses **35** are received in the first slot **316**, with each of the N first lenses **35** optically coupling with corresponding one of the remaining optical channels **313**. Therefore, one of the N+1 first lenses **35** is unused.

The second ferrule **33** comprises N second mirrors **36** arranged in a row, and N+1 second lenses **37** arranged in another row, the second lenses **37** disposed spaced apart from the second mirrors **36**. The second lenses **37** are arranged side by side, and the second mirrors **36** are arranged spaced apart with each other. Each of the second lenses **37** is offset with corresponding one second mirror **36**. The second lenses **37** and the second mirrors **36** are disposed on the second bottom wall **330**. The second lenses **37** are disposed closer to the second post **333** than the second mirrors **36**. The N second mirrors **36** are received in the second holes **318**, respectively, with each second mirrors **36** optically coupling with corresponding one of the N of the 2N optical channels **313**. The N of the N+1 second lenses **37** are received in the second slot **319**, with each of the N second lens **37** optically coupling with corresponding one of the remaining N of the N+1 optical channels **313**. Therefore, one of the N+1 second lenses **37** is unused. As shown in FIG. **5**, in this embodiment, the unused first lens **35** is disposed at the outmost side adjacent to the second ferrule **33**, and the unused second lens **37** is disposed at the outmost side adjacent to the first ferrule **33**, when the first and the second ferrule **32**, **33** are dispose side by side at a same plane. In other word, the unused first lenses **35** is disposed at a side of the first ferrule **32**, and the unused second lenses **37** is disposed at an opposite side of the second ferrule **33**, when the first ferrule and the second ferrule **32**, **33** are disposed side by side in a same plane.

Referring to FIGS. **3** to **6**, the optical module comprises a first lens array **40** received in the first receiving hole **325** of the first ferrules **32**, and a second lens array **50** received in the second hole **335** of the second ferrule **33**. The first lens array **40** comprises 2N first optical lenses **401** arranged with two rows, both rows having N first optical lenses **401**. The second lens array **50** comprises 2N second optical lenses **501** arranged with two rows, both rows having N second optical lenses **501**. The first post **323** mats with a first through hole **314** to accurately position the optical waveguide **31** to the first ferrule **32**. Therefore, one row of the first optical lenses **401** are optically coupling with the first lenses **35**, respectively, and the other row of the first optical lenses **401** are optically coupling with the first mirrors **34**, respectively. The second post **333** mats with the second through hole **317** to accurately position the optical waveguide **31** to the second ferrule **3**. Therefore, one row of the second optical lenses **501** are optically coupling with the N of the N+1 second lenses **37**, respectively, and the other row of the second optical lenses **502** are optically coupling with the second mirrors **36**. N of the 2N channels **313** are optically coupling the N of the N+1 first lenses **35** with the N second mirrors **36**, and the remaining N of the 2N channels **313** are optically coupling the N first mirrors **34** with the N of the N+1 second lenses **37**. The N of the 2N optical channels **313** are alternately arranged with the remaining N of the 2N optical channels **313**, respectively. As the receivers **101** of the line card **20** are upwardly moved a half pitch, and the receivers **201** of the switch card **10** are downwardly moved a half pitch. Therefore, the receiver **101** of the line card **20** and the transmitter **202** of the switch card **10** are optically connected by the optical module **30**, when the line card **20** and the switch card **10** are inserted into the backplane along a same direction.

It is to be understood, however, that even though numerous characteristics and advanarmes of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. An optical module comprising:

an optical waveguide having a first end and a second end opposite to the first end, the optical waveguide comprising 2N optical channels extending between the first end and the second end;

a first ferrule connected with the first end of the optical waveguide, the first ferrule comprising N first mirrors arranged in one row, and N+1 first lenses arranged in another row, the first lenses disposed spaced apart from the first mirrors; and

a second ferrule connected with the second end of the optical waveguide, the second ferrule comprising N second mirrors arranged in one row, and N+1 second lenses arranged in another row, the second lenses disposed spaced apart from the second mirrors;

wherein N of the 2N optical channels optically couple the N first mirrors with N of the N+1 second lenses, with the remaining one of the N+1 second lenses unused, and the remaining N of the 2N optical channels couple N of the N+1 first lenses with the N second mirrors, with the remaining one of the N+1 first lenses unused.

2. The optical module as recited in claim **1**, wherein the N of the 2N optical channels are alternately arranged with the remaining N of the 2N optical channels, respectively.

3. The optical module as recited in claim **2**, wherein the first ferrule comprises a first flat bottom wall and a pair of opposite first side walls extending upwardly from the first bottom wall, a first receiving space formed by the first bottom wall and the first side walls, the first end of the optical waveguide received in the first receiving space.

4. The optical module as recited in claim **3**, wherein the first lenses are arranged side by side, and the first mirrors are arranged spaced apart from each other.

5. The optical module as recited in claim **4**, wherein each of the first lenses is offset with corresponding one first mirror.

6. The optical module as recited in claim **5**, wherein the first lenses and the first mirrors are disposed on the first bottom wall.

7. The optical module as recited in claim **6**, wherein the first end of the waveguide defines a slot for receiving the first lenses, and a plurality of holes for receiving the first mirrors respectively.

8. The optical module as recited in claim **7**, further comprising a lens array received in the first bottom wall, the lens array comprising two rows of optical lenses optically connecting with the first lenses and the first mirrors, respectively.

9. The optical module as recited in claim **8**, wherein the first ferrule comprises a post disposed on the first bottom wall and projected into the first receiving space, and the first end of the waveguide defines a through hole for mating with the post.

10. The optical module as recited in claim **9**, wherein the first ferrule comprises a pair of mounting posts disposed on the bottom wall for mounting to an outer device.

11. The optical module as recited in claim **1**, wherein the unused first lens is disposed at a side of the first ferrule, and the unused second lens is disposed at an opposite side of the second ferrule, when the first ferrule and the second ferrule are disposed side by side in a same plane.

12. An optical module comprising:

a ferrule including a first row of mirrors densely arranged with one another along a transverse direction with a pitch; and

a second row of lenses densely arranged with one another along said transverse direction with said pitch; wherein

an amount of said mirrors is less than that of the lenses by only one, and said mirrors are not respectively aligned with said lenses along a front-to-back direction perpendicular to said transverse direction but at an offset with one half of said pitch;

further comprising another identical optical module with an optical waveguide connected therebetween, wherein said optical waveguide includes a plurality of optical channels, an amount of said optical channels being equal to twice of the amount of said mirrors, the optical channels optically coupling with the mirrors and the lenses, respectively, with one lens unused on each of said optical modules.

13. An optical module comprising:

an optical waveguide having a first end and a second end opposite to the first end, the optical waveguide comprising 2N optical channels extending between the first end and the second end;

a first ferrule connected with the first end of the optical waveguide, the first ferrule comprising N first mirrors arranged in one row, and N+1 first lenses arranged in another row, the first lenses disposed spaced apart from the first mirrors; and

a second ferrule connected with the second end of the optical waveguide, the second ferrule comprising N second mirrors arranged in one row, and N+1 second lenses arranged in another row, the second lenses disposed spaced apart from the second mirrors;

wherein N of the 2N optical channels optically couple the N first mirrors with N of the N+1 second lenses, and the remaining N of the 2N optical channels couple N of the N+1 first lenses with the N second mirrors;

wherein the N of the 2N optical channels are alternately arranged with the remaining N of the 2N optical channels, respectively;

wherein the first ferrule comprises a first flat bottom wall and a pair of opposite first side walls extending upwardly from the first bottom wall, a first receiving space formed by the first bottom wall and the first side walls, the first end of the optical waveguide received in the first receiving space;

wherein the first lenses are arranged side by side, and the first mirrors are arranged spaced apart from each other;

wherein each of the first lenses is offset with corresponding one first mirror;

wherein the first lenses and the first mirrors are disposed on the first bottom wall;

wherein the first end of the waveguide defines a slot for receiving the first lenses, and a plurality of holes for receiving the first mirrors respectively.

14. The optical module as recited in claim **13**, further comprising a lens array received in the first bottom wall, the lens array comprising two rows of optical lenses and optically connecting with the first lenses and the first mirrors respectively.

15. The optical module as recited in claim **14**, wherein the first ferrule comprises a post disposed on the first bottom wall and projected into the first receiving space, and the first end of the waveguide defines a through hole for mating with the post.

16. The optical module as recited in claim **15**, wherein the first ferrule comprises a pair of mounting posts disposed on the bottom wall for mounting to an outer device.

17. The optical module as recited in claim **13**, wherein the unused first lens is disposed at a side of the first ferrule, and the unused second lens is disposed at an opposite side of the second ferrule, when the first ferrule and the second ferrule are disposed side by side in a same plane.

* * * * *